Executive Summary

Introduction

The Mumford River Basin, with a drainage area of 56.6 mi^2, is located in the south central part of Massachusetts (MA) and originates in the towns of Douglas and Sutton, MA. The river flows in a general easterly direction before emptying into the Blackstone River at Uxbridge, MA as shown in Figures E-1 and E-2.

Over the last few years citizens and local organizations such as the Blackstone River Watershed Association have expressed concern regarding low flow levels in the Mumford River. One local resident, Mr. Mike Yacino[1], who has lived on the Mumford River in Douglas for over 60 years, first noticed low flow problems on the Mumford River in the summer of 1999. It was reported that these conditions returned in the summers of 2000 and 2001 and that some sections of the river ceased to flow during these periods. The Executive Office of Environmental Affairs (EOEA) Watershed Initiative and the Blackstone River Watershed Team commissioned a study to investigate recurring low-flow observations in the Mumford River. The purpose of this study was to confirm if reported low flows were present during the past few summers and if so, to identify the potential causes of low flow conditions.

To help identify potential causes of low flows the following information was obtained or developed as part of this study.

- Water withdrawals registered and permitted under the Water Management Act (WMA) in Massachusetts were evaluated to determine the impact those withdrawals were having on streamflow (only water withdrawals greater than 100,000 gallons per day, GPD are subject to the WMA).
- The operations of numerous dams in the basin were investigated to determine if their operations were causing low flow conditions.
- Historic trends in land use were evaluated using available Mass-GIS coverages.
- The major hydrologic components of the watershed were examined. These parameters included: precipitation, streamflow, groundwater levels, water supply withdrawals and wastewater discharges.
- There is no long-term flow monitoring gage currently in operation on the Mumford River, making it difficult to evaluate long term flow trends[2]. To have a better grasp of current flow conditions, two staff gages were placed at key locations in the Mumford River and discharge rating curves were developed for each gage. The staff gages were read by volunteers to develop a database of flow conditions for the period June through September, 2003. This

[1] Mr. Yacino specifically noted low flow conditions on the bridge on Manchaug Road (near the St. Denis Cemetery) in Douglas. He also observed low flows emanating from Potter Road Dam. Mr. Yacino lives just before Soldiers Field in Douglas and observed low water levels in that area as well as through the center of Douglas down to the Gilboa Pond Dam. He also suggested that the impoundments to the left and right of Lackey Dam Road are also a great indicator of low flows given the weed proliferation especially in 2001 and 2002. He also observed stagnant water just before entering Whitinsville.

[2] There was a United States Geological Survey gage on the Mumford River in Douglas from 1939-51.

period happened to be one of the wetter summers in the last few years, thus it was difficult to duplicate low flow conditions in the summers of 1999-2002.

Summary of Key Study Findings and Results

Dams

There are approximately 37 dams located on tributaries and on the mainstem in the Mumford River Basin- this is a high number of dams relative to the drainage area size of 56.6 mi^2. In fact there are 13 mainstem dams over a distance of 13.5 miles- approximately one dam every river mile. The following summarizes our findings of dam operations:

- Most of the Mumford River mainstem dams are abandoned and ownership could not be determined. Based on our site reconnaissance, it appeared that these dams now function as run-of-river facilities. Most of these dams did not have low level outlets or gates that are typically used to regulate flow.

- Many dams are actively managed during the spring when flashboards are installed, and in the fall when flashboards are removed. Installing flashboards in the spring could artificially reduce the discharge to leakage while the impoundment fills (unless the facility has a low level gate). In the fall, flashboard removal could create artificially high flows. During the summer, when flows are traditionally the lowest, owners that could be contacted indicated that the facilities are not regulated, rather inflow equals outflow on a continuous basis. Typically, flashboard removal/installation was used for a variety of purposes including recreation use in the summer, weed control in the fall, and minor storage capacity during the spring runoff.

- Based on Gomez and Sullivan's research, dams that regulate flow on a daily and seasonal basis include: Manchaug and Whitin Reservoirs and Reservoir Nos. 6, 5, and 4 (total of 5 projects). These five reservoirs are seasonally operated by regulating discharges (see Figure E-2 for dam locations).

  Manchaug and Whitin Reservoirs collectively control a large portion of the Mumford River flow. These two reservoirs have significant storage capacity and are heavily regulated throughout the year. The reservoirs are actively managed; however, there is recognition that a balance is needed between recreational interests/lakeshore residents and downstream aquatic and assimilation needs. The reservoirs are drawn down, as needed, in the summer to maintain a continuous flow of 16 cubic feet per second (cfs) below Gilboa Dam, (see Figure E-2), which has a drainage area of approximately 31 mi^2. Thus, the minimum flow is equivalent to approximately 0.5 cfs per square mile of drainage area. The minimum flow is required for two purposes: a) to assimilate discharges from two National Pollutant Discharge Elimination Systems (NPDES) dischargers located further downstream on the Mumford River in East Douglas (see Figure E-2) and b) to provide sufficient flow for aquatic resources[3]. During the fall, the reservoirs are lowered further to create sufficient storage for

[3] Per IFGF's letter of October 31, 2003, the flow needed to assimilate their NPDES discharge is less than 16 cfs.

the spring freshet. In short, these two reservoirs artificially regulate flow by augmenting low flows in the summer and fall, and decreasing flows during the spring runoff.

The other three reservoirs, located in a series on Cook Allen Brook, are Reservoir Nos. 6, 5, and 4, which are considerably smaller than Manchaug and Whitin Reservoirs. The reservoirs are seasonally operated to maintain flow below Reservoir No. 4, the lowermost reservoir for public water supply withdrawals by Whitinsville Water Company. During the summer, when water demands typically peak, the reservoirs are drawn down to meet water supply demands.

Overall, it does not appear that dam operations are causing low flow conditions (with the exception of Reservoir Nos. 6, 5 and 4) in the Mumford River during the summer. In fact, Manchaug and Whitin Reservoirs supplement naturally low flow conditions by reducing impoundment levels in the summer to maintain 16 cfs below Gilboa Pond.

Water Withdrawals

There are four water withdrawals in the Mumford River Basin that are currently registered and/or permitted with the Massachusetts Department of Environmental Protection (MDEP) under the Water Management Act as shown in Figure E-2. They include the Whitinsville Water Company (WWC), Douglas Water Department (DWD), Interface Fabrics Group Finishing (IFGF) and the Whitinsville Golf Course (WGC). An analysis of 1998-2001 water withdrawal records was conducted. On an average annual basis, the major water users were WWC (70 %), followed by DWD (15%), IFGF (13%) and WGC (2%). The total average annual withdrawal for the period 1998-2001 was 656.7 million gallons (MG), which is equivalent to 1.8 million gallons per day (MGD) or 2.8 cfs annually. Average peak water usage typically occurs during July (68 MG) and June (66 MG), which is equivalent to approximately 2.2 MGD or 3.4 cfs during these months.

Water usage for WWC has increased by 25% from 1998 to 2001 and by 9% over a longer period 1996-2002[4]. If water use trends continue, WWC may exceed their allowable water withdrawal before February 2004. WWC supplies water to customers within the Mumford River Basin, and also sells water to the town of Northbridge, which is outside the Mumford River. Withdrawals are also occasionally trucked (2 out of the 4 years examined in this study) to the Milford, MA Power plant during summer months for cooling water use. A large portion of the WWC service territory has a sewer system with wastewater flowing to the Northbridge WWTP located on the Blackstone River. Infiltration and inflow to the sewer system is also carried out of the Mumford Basin.

DWD withdraws groundwater from four wells located within the Centerville and Riddle Brook subwatersheds of the Mumford River. DWD water usage has increased by 4% over the last four years. All of DWD's service territory is located in the Mumford River Basin. In addition, the East Douglas sewer system collects and discharges water only within the Mumford watershed. Thus, there is no out of basin water transfers- the only losses are attributable to evapotranspiration and evaporation.

[4] Gomez and Sullivan's study focused on the period 1998-2001. WWC provided us with historical annual water usage from 1996-2002, which showed a percent increase of 9%.

IFGF withdrawals have steadily decreased over time, dropping by 27% between 1998 and 2001. They have implemented aggressive water conservation measures to help reduce water demands. In 2001, annual water withdrawals were 73 MG or 0.3 cfs (summer withdrawals were also around 0.3 cfs), which is well below their authorized annual withdrawal of 547 MG. According to IFGF, there is little water consumed in their processes- most water is returned to the Mumford River via their treatment plant discharge. On an annual basis there was a minor difference between their water withdrawal volume and the NPDES return volume in 2000 and 2001. However, on a monthly basis some water is consumed in IFGF's processing, but the exact amount could not be determined in this study.

WGC also withdraws water from the Mumford Basin during the golf season (generally late April through October). Their total withdrawal in 2001 was 14.2 MG over 180 days, with peak usage occurring in August of 3.3 MG (0.16 cfs). It is estimated that half of WGC's withdrawals are lost to evaporation and evapotranspiration.

Shown in Table E-1 is a summary of the estimated volume of water lost from the Mumford River Basin from these four WMA users.

Table E-1: Annual and Monthly Volumes of Water Lost to Evaporation or Transported out of the Mumford River Basin due to Water Withdrawals. Averages based on the period 1998-2001.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
TOTAL (in MGD)												
0.65	0.67	0.66	0.72	0.98	1.07	1.09	0.96	0.84	0.69	0.65	0.66	0.80
TOTAL (in cfs)												
1.00	1.04	1.02	1.12	1.51	1.66	1.68	1.48	1.29	1.07	1.01	1.02	1.24

Precipitation, Streamflow, and Upstream Storage Regulation

Historic and recent precipitation data were evaluated to determine if observed low flow conditions could also be a function of below-average precipitation levels. The analysis indicated that both the spring and summer of 1999 were one of the drier periods on record with virtually no precipitation occurring in June. Similarly, during July and August 2002, precipitation levels were also quite low. Summer precipitation levels in 2000 and 2001 were within average range. Based on this analysis, further evaluation in streamflow records was conducted.

Historically, a United States Geological Survey (USGS) streamflow gage was located on the Mumford River in Douglas (drainage area = 29.1 mi^2) from October 1, 1939 and September 30, 1951. An analysis of the historical flow data from this gage is presented in this report; however, to evaluate more recent flow trends in this area, we relied on a staff gage located below Gilboa Pond and operated by IFGF (although the accuracy of the gage may be questionable). The approximate drainage area of the staff gage is 31 mi^2, slightly larger than the retired USGS gage site. According to IFGF, the gage is calibrated every five years and is accurate up to 50 cfs, while flows between 50-100 cfs are estimated by IFGF. Flows are recorded daily, based on instantaneous measurements.

IFGF also provided 1999-2002 daily water level recordings at Manchaug and Whitin Reservoirs. Within the report are numerous plots depicting the relationship between precipitation, streamflow and water levels at Manchaug and Whitin Reservoirs for common periods of record. A few key observations could be gleaned from the study as follows.

- In most instances, after a precipitation event streamflow increased as expected.
- There were instances where the IFGF staff gage flows remained constant over several months of the summer, although there were many precipitation events during the same period.
- During most summer precipitation events, Manchaug and Whitin Reservoirs stored inflow, resulting in lower than natural flow conditions below the projects. The two facilities control 15.6 mi^2 of the drainage area at the IFGF staff gage (31 mi^2) or half of the drainage area.
- Based on the data provided by IFGF regarding gage flow records for the period 1999-2002, flows never dropped below 16 cfs, the minimum flow requirement.

In addition to the analysis of 1999-2002 data, the IFGF staff gage was supplemented with two additional staff gages placed upstream (at Potter Road Dam-22.6 mi^2) and downstream (Douglas Street Dam-48.3 mi^2) of the IFGF gage- see Figure E-3. Over the summer of 2003 staff gage rating curves were developed by obtaining a series of flow measurements that were related to staff gage heights. Volunteers read the two gages on a daily basis (instantaneously) between June 4 and September 15, 2003 and gage measurements were converted to flow via rating curves. In general, the summer of 2003 was considered wet relative to the summers of 1999-2002. There were instances during the summer of 2003 when measured flows at Potter Road and Douglas Bridge fell below 16 cfs, the minimum flow required below Gilboa Dam at the IFGF gage. The lowest measured flows were 14.6 and 14.7 cfs, at the Potter Road and Douglas Bridge gages, respectively. In short, there may have been instances when the true flow was below 16 cfs at the IFGF gage.

Discussion and Recommendations

General recommendations were developed to address issues that were encountered during the study process.

- It is recommended that the MDEP improve efforts to verify the accuracy of data reported on Public Water Supply Annual Statistical and Registered & Permitted Withdrawals Annual Reports as part of the Water Management Act. Some of the reported values were well outside the "normal" range.

- Hard copies of the Public Water Supply Annual Statistical Reports and Registered & Permitted Withdrawals Annual Reports were obtained by visiting the MDEP offices. The data from these reports were then keypunched into spreadsheets such that various graphs could be developed to evaluate the data. It would be extremely beneficial if water users were able to enter the data requested on the forms via an on-line reporting system. A computerized database would help in managing overall water uses and would reduce the time

needed to keypunch data. This approach would also allow outlier values to be readily identified.

Dams

- In Gomez and Sullivan's limited research, we could not locate many of the dam owners and thus assumed that the dam was abandoned. It is recommended that further investigation into dam ownership be undertaken for two purposes. First, many of the dams have outlived their intended purpose, and may pose safety issues. Secondly, identifying the dam ownership would provide further information on the specific operation of the facility.

- There are numerous dams in the Mumford River Basin. The adverse impact of dams on fish, wildlife, wetlands, Threatened and Endangered species, water quality and other environmental resources is well documented in the literature. Given that many of the Mumford River dams have outlived their intended purpose, consideration should be given to potential dam removals.

- There is currently no gate rating curve that has been confirmed at the outlet of Manchaug and Whitin Reservoirs. Because the reservoirs highly regulate flow and control a major portion of the river flow, it is recommended that gages be placed just downstream of Manchaug and Whitin Reservoirs.

- It is recommended that IFGF strive to manage releases from Manchaug and Whitin Reservoirs to mimic the natural response to precipitation events. In many instances, flow at the staff gage remained constant even though precipitation events occurred. Although this recommendation is provided, it is recognized that recreation interests and homeowners around the lake will want to have a balance between summer recreation water levels and downstream aquatic resources.

- At many of the smaller dams flashboards are installed just after the spring runoff and removed in the fall. Once flashboards are affixed to the spillway crest, there may be several hours or days before the impoundment fills (depending on the impoundment size, contributing drainage area and height of the flashboards) to the flashboard crest. While the impoundment fills, no flow is conveyed below the dam unless a low level gate is opened. In some instances flow can be reduced to only leakage, which impacts downstream aquatic resources. It is recommended that a continuous minimum flow be provided below these dams when the flashboards are reinstalled

- It is recommended that all dams in the Mumford River Basin that regulate discharges should be operated to maintain continuous seasonal minimum flows throughout the year. Most dams under the State's jurisdiction are not necessarily required to maintain a continuous minimum flow. Absent any detailed studies, we recommend defaulting to at least the seasonal minimum flows set forth in the USFWS New England Regional Flow Policy as follows.

Period	Fall/Winter (Oct-Mar)	Spring (Apr)	Summer (May-Sept)
Flow per square mile	1.0 cfsm	4.0 cfsm for the entire applicable spawning and incubation periods	0.5 cfsm as derived from the median August Flow

Maintaining continuous seasonal minimum flows will help ensure that aquatic resources in the riverine reaches below the dams are protected. Obviously, for Manchaug and Whitin Reservoirs these flow recommendations could result in lowering the impoundments in the summer, which could create issues with homeowners, camps and summer recreation interests. Lowering the impoundments in the summer could also have similar environmental impacts on the littoral zone which could become dewatered. Thus, some negotiation of summer flows may be required for Manchaug and Whitin Reservoirs.

- Aldrich Pond, which is part of the Sutton Falls Campground, is located on a tributary to Manchaug Reservoir. A local resident indicated that in 2002, algae and other pollutants were discharged from Aldrich Pond into Manchaug Reservoir at the conclusion of the camping season when the gate was opened to lower the pond level. There is concern that a large influx of pollutants compromised the water quality of Manchaug Reservoir. Testing by Lycott Associates reportedly indicated that large amounts of phosphorus enter Manchaug Reservoir from Sutton Falls Dam. Large quantities of watermeal were also detected by the MA Department of Environmental Protection. It is recommended that the source causing pollutants to enter the stream system be evaluated and controlled. It is also recommended that the need for regular fall drawdowns be demonstrated.

Water Supplies

- There is no method to accurately track the amount of water transferred out of basin. More accurate information is needed on the amount of water leaving the Mumford River Basin prior to its confluence with the Blackstone River in Uxbridge.

- It is recommended that WWC and DWD take measures to further conserve water. This will require increased public outreach and education to end-users of the need for water conservation, particularly during critical low flow periods.

- Most low flow events occur in the summer when water supply demands are the highest, resulting in even greater stress on already low flowing rivers. For WWC and DWD, the ratio of peak demand to average daily demand was computed to determine the magnitude of summer usage. The peak factors were 1.74 for WWC and 1.90 for DWD. Through aggressive water conservation measures and public outreach, WWC and DWD should strive to limit this ratio to 1.5, as well as cap gallons per capita day (gpcd) use to 65. In addition, DWD should limit unaccounted for water to 10% or less if possible. Leak detection surveys and repairs should be conducted on an annual basis, if possible.

- It is recommended that WWC and DWD project future water supply needs in the years 2005, 2010 and 2020 based on population growth. The Commonwealth of Massachusetts' methods for forecasting future demand should be implemented for these suppliers. The concern is that water withdrawals will continue to increase, resulting in even greater stress on the Mumford River flows and tributaries. In the case of WWC, a portion of future withdrawals will likely continue to be transferred to the Northbridge WWTP for treatment. In the case of DWD, it is unknown if the East Douglas WWTP could absorb the projected increase in water use. By forecasting future usage, the town of Douglas can plan in advance any potential upgrades to their WWTP to handle future loads.

- It is recommended that trucking water from Meadow Pond to the Milford, MA Power plant be discontinued as it results in a direct loss of water from the Mumford River Basin during the low flow summer months

- The Whitinsville Golf Club does not have any water conservation policy in place. It is recommended that a water conservation plan or drought management plan be developed in consultation with the state. At the very least, it is recommended that golf course irrigation occur during the evening or early morning when evaporation is the lowest. In addition, during critically dry periods, it is recommended that watering be localized to only putting greens.

- IFGF has taken great strides to reduce water consumption. It is recommended that IFGF continue their efforts to reduce water consumption in the future.

Flow

- Water withdrawals contribute to low flows, as do the operation of some dams. In addition, during the summers of 1999 and 2002 precipitation levels were low, resulting in less streamflow.

- Based on the study findings, extremely low flows on the Mumford River in 1998-2001 could not be verified by our findings. In fact, without the flow augmentation provided by Whitin and Manchaug Reservoirs, summer flows would be even lower- closer to natural conditions. The USGS Streamstats[5] analysis indicated that under an unregulated river system Mumford River flows would be well below current regulated levels in the summer. The August median flow based on the retired USGS gage flow data was 23 cfs (0.79 cfsm) as compared to 5 cfs (0.17 cfsm) based on Streamstats. Relative to unregulated rivers in New England, the regulated August median flow (23 cfs) is considered high. In addition, although the IFGF gage requires recalibration, the minimum flow requirement since 1986 is 16 cfs below Gilboa Pond, which is roughly 0.5 cfsm- this is equivalent to the USFWS Aquatic Base Flow.

- There are times when the flows measured at the IFGF staff gage are not balanced with flow measurements and readings at Potter Road Dam and Douglas Dam. In some instances, the

[5] Streamstats is a model developed by the US Geological Survey that estimates unregulated flow statistics for a river basin.

flows were greater at Potter Road Dam as compared to the IFGF gage even though Potter Road is upstream. It is recommended that the IFGF gage be recalibrated and relocated to improve the accuracy of flow readings.

Although not highly recommended, if there remains a concern regarding low flows caused by regulation then additional flow monitoring may be implemented. Much of our analysis of pre-2003 data was based on the IFGF staff gage, which may be inaccurate at times. Currently, three staff gages are available, but they must be read manually to obtain instantaneously flow levels. In addition, two of the gages installed as part of this study were read by volunteers, which have been discontinued. Since rating curves have already been developed for these three staff gages, continuous water level recorders could be placed at all three sites and river stages could be converted to flow via the rating curves. Having long-term flow data for these three stations would help in evaluating flow trends and compliance with the 16 cfs release requirement. In addition, flow data in unregulated subwatersheds would provide baseline conditions for comparison purposes.

Development

- To help limit the amount of runoff entering stormwater systems, homeowners should be encouraged to utilize cisterns and rain barrels to collect and store rainwater for outdoor use.

- Between 1971 and 1999, residential land use in the Mumford River Basin increased by 7.9%, while forested land decreased by 8.6%. Development in the basin will impact the timing and magnitude of Mumford River streamflows. To limit the impact of future development, it is recommended that local planning boards carefully scrutinize new applications for large-scale developments (i.e., large subdivisions, golf courses, etc.). Planning Boards may wish to consider implementing a water bank or otherwise mandate mitigation measures to off-set the impacts of future developments to assure these do not place further demands on the water systems and exacerbate low-flow conditions.